DEVELOPMENT OF A PERSONALIZED WIRELESS ATTENDER CALLING SYSTEM FOR CRITICAL PATIENT MANAGEMENT

A THESIS SUBMITTED IN PARTIAL FULFILLMENT

OF THE REQUIREMENTS FOR THE DEGREE OF

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By

DEBESHI DUTTA

212BM1353

Under the Supervision of

Dr. INDRANIL BANERJEE

Department of Biotechnology & Medical Engineering

National Institute of Technology

Rourkela-769008, Odisha, India

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CERTIFICATE

This is to certify that research project report entitled "**Development of a Personalized Wireless Attender Calling System for Critical Patient Management**" submitted by **Debeshi Dutta**, in partial fulfillment of the requirements for the award of the Degree of Master of Technology Biotechnology and Medical Engineering with specialization in Biomedical Engineering at National Institute of Technology Rourkela is an authentic work carried out by her under my supervision and guidance.

To the best of my knowledge, the matter embodied in the thesis has not been submitted to any other University/ Institute for the award of any Degree or Diploma.

Dr. Indranil Banerjee

Assistant Professor

Department of Biotechnology and Medical Engineering

National Institute of Technology, Rourkela

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CONTENTS

ABSTRACT

There is a need of a smart attender calling system for efficient patient care in modern hospitals. Such a system is needed in medical institutions in order to help certain critically disabled patients (temporarily disabled for vocal communication or mobility) to reach their health care givers or doctors by very simple means. Keeping the aforesaid perspective in mind, here we have developed a personalized wireless body–fixed attender calling system. The device is prepared by assembling a flex sensor and a Hall Effect sensor on hand glove platform effective through hand movement of the user. A trained finger movement and hand position change of the patient lead to flexion induced variation in output voltage and change in Hall sensitivity. The circuit consists of a flex-hall arrangement interfaced with Arduino UNO board loaded with suitable commands for desired analog read and wireless serial transmission of data. Above a preset threshold level the proposed device will get activated and start its play and display function. As a result, patient identification information accompanied with a message will be delivered to the concerned medical person. The sensitivity of the setup can be adjusted by manipulating the preset threshold value as per the requirement of the patient. It is believed that the aforesaid system could be useful for efficient patient management thereby reducing unfortunate situations in modern medical treatments.

Keywords: Critically disabled, Flex-Hall, Arduino UNO, threshold value.

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CHAPTER 1

INTRODUCTION AND LITERATURE REVIEW

1.1 Introduction

With the advancement in technology, treatment approaches adopted by modern hospitals have gone through drastic improvements. The concept of a simple hospital is changing into a “smart hospital”. The advancement of treatment technology in such a “smart hospital” has increased the safety and security of its patients. Patients with critical conditions usually need the care of doctors or health care givers at any point of time. But usually it becomes difficult for the hospital authority to provide a constant monitoring to each patient by providing an attender by the patient side 24 X 7. Hence, the patient faces difficulty to communicate with the care-giver in times of emergency. Such lack of communication often leads to unfortunate circumstances due to late treatment. Smart hospitals have incorporated advanced systems and technologies for improved patient care with better patient attending facilities. A better medical care involves an instant care facility for the needy. The integration of medical science with engineering has led to the invention of devices that play artificial speech for the needy. These systems enable them to drag the attention of health caregivers as required. Earlier, remote control technology was used for this purpose. Nowadays, scientists have come up with hand movement based talking devices for patients. Such device is usually a glove-based wearable worn by target patients in order to serve various purposes.Since our primary physical connection to the world is through our hands and we perform most everyday tasks with them, [1] such devices are encouraged to be used for convenience, flexibility, accuracy and, cost effectiveness.

The first hand talk glove was designed by Ryan Patterson in the year 2001, with an attempt to translate sign language into speech for the deaf. Inspired from such a device, a sensor equipped hand talk glove was developed in later years that used sensors to pick up hand gestures and transmit data wirelessly via Bluetooth to a cellphone where data can be converted to text and voice output. Different sensors have been used by scientists in order to detect such gestures, the basic principle being the transducing of hand movement into electrical signals. Data Glove was introduced by VPL research and employs the optical fiber technology for flexion detection and a magnetic sensor for position tracking. Data gloveswere used to translate ASL alphabetin human computer interaction (HCI) with applications in human robot interface and hands free speech recognition.

Another kind of glove based device called Z-Glove employs an ultrasonic positioning and orientation system [2-3]. Cyber glove and power glove have further overcome the drawbacks faced by the data gloves [4]. Hall Effect sensors attached to human hand gloves have also been used as position sensors; to measure fingers' range of motion (ROM) [5]. Further innovations have revealed a class of wearable and stretchable devices fabricated from thin films of aligned single-walled carbon nanotubes for human motion analysis [6]. Wearable inertial sensors placed near the wrist and elbow joints were also used for human motion tracking. Each of these inertial sensors comprised of a tri-axial accelerometer, a tri-axial gyroscope and a tri-axial magnetometer [7]. However, few of these devices are found expensive, complicated and may be out of reach for the common people of third world countries.

Keeping the aforementioned perspective in mind we have developed a flex sensor and Hall Effect sensor based simple device for finger movement responsive attender calling. Flex sensor is a type of variable resistors which when bent from one end change their resistances. Data was acquired from this sensor once coupled with appropriate circuitry. This data was processed using relevant commands in order to obtain desired results. These sensors are mounted on the light-weight glove and connected to the driving hardware via small cables [3]. Hall Effect sensor, being the second sensor used, it is a type of magnetic sensor that adopts the Hall Effect phenomenon for its working. This sensor is responsive to a magnetic field and changes its output voltage according to that. A Hall Effect sensor was installed in the hardware circuitry and the magnetic field was produced by a magnetic material attached to the wrist area of the patient's hand glove. A proper interfacing circuitry and relevant commands allowed the device to work in digital (on/off) mode. Hence, the two sensors were combined and assembled on a hand glove platform to act as a health care response system in smart hospitals.

1.2 Review of Literature

The Hand Talk glove designed by Ryan Patterson was initially aimed at Sign language detection and translation. This Hand Talk glove contained ten flex sensors or bend sensors stitched to each finger thereby undertaking the position monitoring of respective finger movements. Electrical resistance was created with bend of finger. The electrical current was converted into digital signals and the corresponding data was transmitted wirelessly to a computer using a microcontroller.The further process and display of data was carried on by the computer. The main drawback of this system constituted the use of computer throughout the process thereby debarring it from being used portably. Hence a portable hand talk device was of real need. Keeping this in mind, researchers have come up with such a hand glove model. In such a model, hand-movement driven sensors identifygestures followed with wireless data transmission via Bluetooth to a mobile phone in form of text. The text to speech converter software installed in the mobile phone plays the text as voice. This device can be preferred due to its portability, simplicity and cost effectiveness. The device could be used for communication efficiency between a deaf person and common people.Researchers have also come up with various other gloves (Power gloves, Cyber gloves, etc.) employed with various other sensors for the detection of hand and finger movement for their application in various fields. Each type of sensor pick up different aspects of patient's body and comes up with desired output. These sensors are usually interfaced with microcontroller IC with supporting electronics. A brief description of the possible hardware components usually required to build an effective human motion detecting device is listed as follows:

1.1 Arduino Platform- A brief description

Arduino UNO is a simple and sophisticated electronics prototyping platform combined with flexible hardware and software. This platform is based on Atmel's ATmega microcontroller. The software is supported by various operating systems like Windows, Macintosh OSX and Linux, though Windows operating system is mostly supported and used. The software language adopted is AVR C programming language and can be expanded through C++ libraries. Several types of Arduino microcontroller boards are available in the market like UNO, Mega, etc. [8].

1.2 Arduino UNO Board

The Arduino UNO Board, latest in Arduino board series, has been chosen as the platform for the proposed device.This board incorporates microcontroller chip ATmega328. As the figure displays, it has 14 digital input/output pins (of which 6 can be used as PWM outputs) and 6 analog inputs. A 16 MHz ceramic resonator, a USB connection, a power jack, an ICSP header, and a reset button are implanted onto the board for several purposes. A single shield comprises of the microcontroller and its supporting shield. The power to this board may be either supplied by simple USB cable connection to a computer or with an AC-to-DC adapter or battery. Unlike other boards available in the market, the UNO is installed with an Atmega16U2 (Atmega8U2 up to version R2) programmed as a USB-to-serial converter instead of using FTDI USB-to-serial driver chip. A total of 32 KB flash memory held by the board of is divided as 0.5 KB for boot-loader, 2 KB for SRAM and 1 KB for EEPROM. It has a clock speed of 16 MHz [9].

Fig 1Arduino UNO Board

Figure 1 shows the Arduino Uno Board manufactured by the Arduino. It is powered by either a USB connection oran external power supply. As evident from the figure 1, pins A0 to A5 are the six analog input pins, pins 0 to 13 are the digital input/output pins and the pins with a "~" sign are the PWM output pins. The digital pins are used as input/output pins for the purpose of analog read. By using the function pin-mode (), mode of pin is selected and then by using the function digitalRead() or digitalWrite() functions of respective pins are assigned. Pins 0(RX) and 1(TX) are assigned for serial communication while pins 10(SS), 11(MOSI), 12(MISO) and 13(SCK) are used for SPI (Serial Peripheral Interface) communication. In addition to pin 0 and 1, a Software Serial library gives way to serial communication on any of the Uno's digital pins. [9]

- **ATMega328 Microcontroller Architecture**

The Arduino UNO Board incorporates the ATMega328 microcontroller chip along with other supporting components in a single shield. This is a low power CMOS (Complementary Metal Oxide Semiconductor) 8-bit microcontroller. The chip is based on the AVR enhanced RISC (Reduced Instruction Set Computer) architecture. An ATMega328 microcontroller chip executes its instructions in a single clock cycle resulting into a gain of 1 MIPS per MHz throughputs [9]

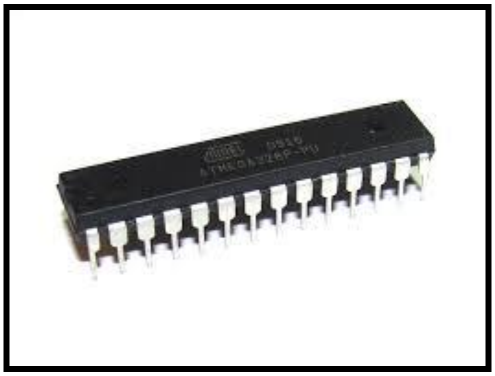


Fig 2 ATMega328 Microcontroller Chip

[http://html.alldatasheet.com/]

Figure 3 shows the internal architecture of ATMega328. The central processing unit (CPU) acts as the brain of the microcontroller. It takes care of proper execution of program. [9] Table 1 briefly states about the memory size of this chip.

The microcontroller chip operates in five different modes. The different modes of the microcontroller chip are: Idle mode, Power-down mode, Power-save mode, ADC Noise Reduction mode and the Standby mode. Therefore the CPU, being the brain of the MCU has an access to memories, can perform calculations, control peripherals and handle interrupts. The Harvard architecture is used by the AVR. [9]

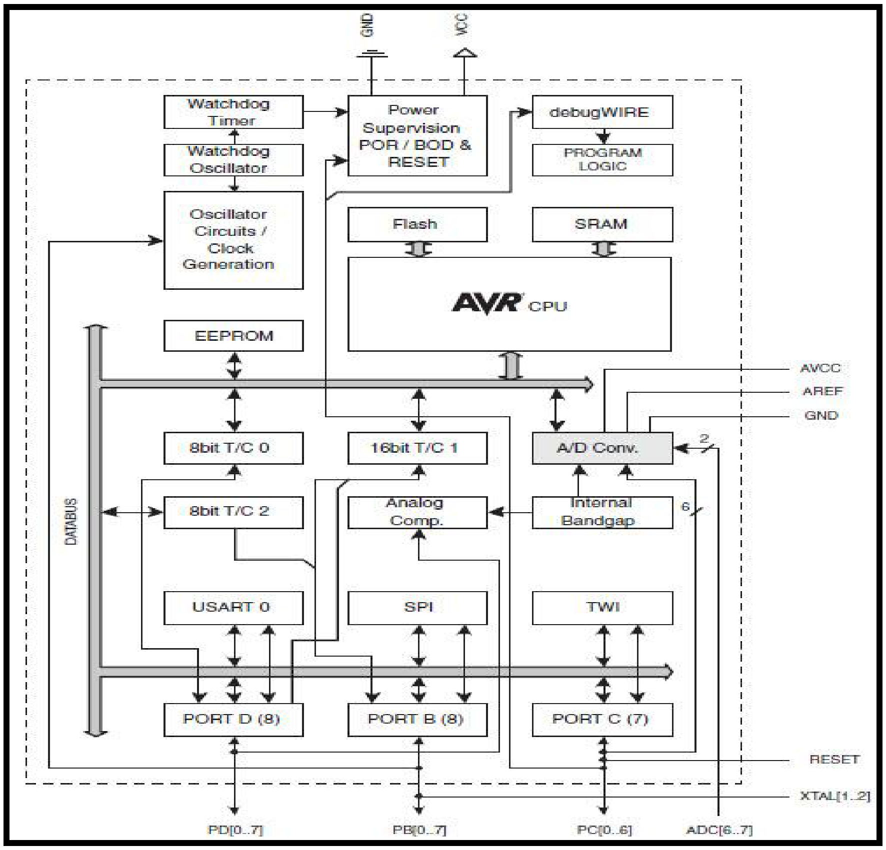


Fig 3 Detailed Architecture of ATMega328 Microcontroller Chip

[http://html.alldatasheet.com]

Flash	EEPROM	RAM	Interrupt Vector Size
32Kbytes	1Kbyte	2KBytes	2 instruction words/vector

Table 1 Memory Size of ATMega328 microcontroller chip

The other features of the microcontroller unit are as follows:

- 23 general purpose I/O lines
- 32 general purpose working registers
- 3 flexible timer/counters
- Internal and external interrupts
- A serial programmable USART
- A byte-oriented 2-wire serial interface
- An SPI serial port
- A 6-channel 10-bit ADC
- A programmable watch-dog timer with an internal oscillator
- 5 software-selectable power saving modes

1.3 XBee Trans-receiver Shield

The XBee family of embedded RF modules has come up with two serias of XBeetrans receivers-series 1, series 2. An XBee module is used to build a low cost, low power wireless sensor network with effective serial communication.The module works in minimal power and is responsible for transmission and reception of data between devices.

From the two different series of XBee module available in market, here we have adopted XBee Series 1 for the proposed device. Series 1 is preferred to series 2 because of certain additional features. Series 2 XBee is always required to be configured to make them working and a linear relationship is needed to set up between the talking XBees (the coordinator and its routers). On the other hand, series 1 XBee can directly be installed without any configuration and allows effective transmission and reception of serial data. Hence, Series 1 XBee provides an easy usage for the purpose of wireless communication.

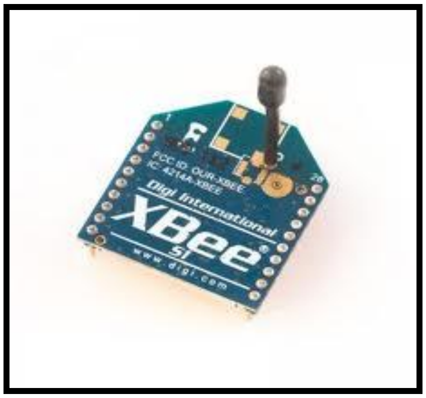


Fig 4 XBee Series 1 module

[http://examples.digi.com/get-started/basic-xbee-802-15-4-chat]

Figure 4 is a series 1 XBee module used for transmission and reception of serial data. The Specification of an XBee Series 1 is discussed below: (Table 2)

1.Performance	
RF Data Rate	250 kbps
Indoor/UrbanRange	100 ft (30m)
Outdoor/ RF Line-of Sight Range	300 ft(100 m)
Transmit power	1 MW
Receiver Sensitivity	-92 dBm
2.Features	
Serial data interface	3.3 V CMOS UART
Configuration Method	API or AT Commands, local or over-the-air
Frequency Band	2.4 GHz
Interference Immunity	DSSS(Direct Sequence Spread Spectrum)
Serial Data Rate	1200bps-250 kbps
ADC Inputs	(6) 10-bit ADC inputs

Digital I/O	8
Antenna Options	Chip, Wire whip, U.FL, RPSMA
3.Networking and Security	
Encryption	128 Bit-APS
Reliable Packet Delivery	Retries/Acknowledgements
IDs and channels	PAN ID, 64-bit IEEE MAC, 16 Channels
4.Power Requirements	
Supply Voltage	2.8-3.4 VDC
Transmit Current	45mA at 3.3 VDC
Receive Current	50mA at 3.3 VDC
Power-down Current	<10uA at 25 °C

Table 2 Specifications of an XBee Series 1

The XBee module is designed to mount into a socket and hence does not require any soldering to mount into the board. RS-232 interface boards are used to mount XBee modules. This set up is compatible with Arduino UNO board and can be programmed to perform specified operations by interfacing it with the Arduino board.[10]

Fig 5 XBee Module mounted to an RS-232 interface board and interfaced with Arduino UNO

1.4 GPRS/GSM Network

Global System for Mobile Communication is abbreviated as GSM. In conventional analog networks, subscription and mobile equipment are the same whereas; in the GSM subscription and mobile equipment are separated. The subscription constitutes the smart card monitoring and subscriber's data storage in the SIM (Subscriber Identity Module) cardwhereas the mobile equipment is provided by the radio equipment. Hence, the mobile station is the combination of the SIM and radio/mobile equipment. Among all other services, SMS (Short Messaging Service) is a service supported by the GSM which deals with sending of short messages to and from the mobile stations. SMS is controlled by the SMSC (Short Message Service Center) supported by the GSM network messages transfer between the SMSC and the mobile stations. [8]

General Packet Radio Service is abbreviated as GPRS. It employs a transmission service through a packet-switched set upthat supplements data obtained by circuit-switched set up and the sending of SMS overthe mobile telephone network [8]. Addition of certain new infrastructure nodes and aupdated software to the circuit switched network architecture has upgraded it to a packet. The GPRS data service has removed certain drawbacks faced by SMS and Circuit Switched Data. GPRS is less expensive and allows faster transmission of informationacross the mobile network. Also, it supports several new applications that are not supported over the GSM networks due to the speed limits posed in case of Circuit Switched Data i.e. 9.6 kbps and the length of the SMS i.e. 160 characters. In a GPRS, the information to be transmitted is first split into individual packets that are related to each other and are then reassembled at the receiving end. [8]

- **SIM900 GSM/GPRS Module**

SIM900 is a compact and reliable wireless Surface Mount Technology (SMT) type GSM/GPRS module. It is constructed of a single-chip processor assembled with AMR926EJ-S core. It provides GSM/GPRS 850/900/1800/1900 MHz frequency for voice, SMS and data. The power consumption and current consumption for this module is very low. The current consumed is as low as 1.0mA when in sleep mode.Optimization is done for voice and other forms of data transfer that includes text and images. The dimension of the module is 24 mm x 24 mm x 3 mm. It is designed to serve the requirements for M2M applications. It can be divided into two classes: a) GPRS multi-slot class 10/8, and b) B-type GPRS mobile station class. It is compliant with GSM phase 2/2+, Class 4 (2W@850/900 MHz) and Class 1 (1W@1800/1900 MHz). GSM/GPRS module is interfaced and controlled by AT commands. [8]

Attention is abbreviated as AT. It is not a part of a command rather just a prefix to indicate the start of a command line. For example, D and +CMGR are the actual command names in ATD (Dial) and AT+CMGR (Read SMS Messages) respectively and the pre-fixed ‘AT’ just informs the start of their respective commands. These commands are of two types: basic and extended. Extended commands begin with “+”. GSM AT commands are mostly extended commands. +CMGR (Read SMS Messages), +CMGL (List SMS Messages) and +CMGS (Send SMS Messages) are examples of extended commands. On the other hand, basic commands do not start with a “+”.H (Hook Control), A (Answer), D (Dial) and O (Return to online data state) are a few examples basic commands.

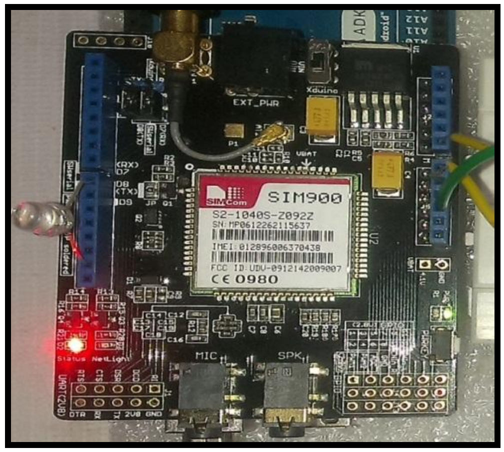
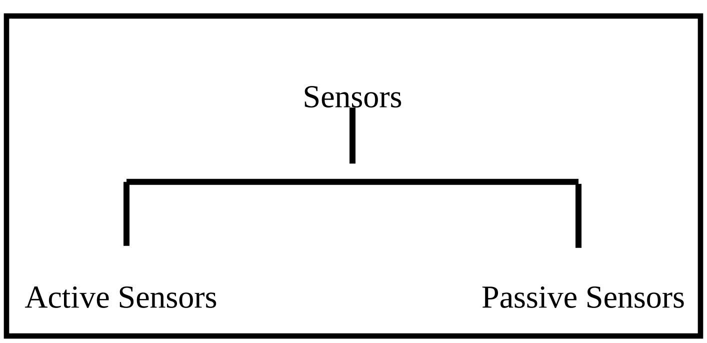


Fig 6 Sim900 GSM/GPRS Module

1.5 Sensor

A sensor is a device or material that senses and measures certain physical quantity and translates it into electrical signals that can be detected by an instrument or read by an observer. Sensing principles are classified into two categories:a) physical and, b) chemical. On the basis of these two sensing principles, sensors can be classified accordingly. The classification of sensors, being a vast field, is not possible to be classified under one criterion. Therefore, they are classified under the categories of material and technology, properties, transduction principles or applications. [11]



A passive sensor receives and detects the signal. On the other hand, an active sensor transmits signal and then measures the signal that is reflected, refracted or scattered.

Response and recovery time, aging, reproducibility, stability, dynamic range, selectivity, size, range and cost are certain important properties of a sensor. The relevance of these properties is based on the application of the sensor. There are several types of sensors. Below is the description of the sensors used for the proposed device.

- **Flex Sensor**

Flex Sensors or Bend Sensors are a type of variable resistors which when bent from one end change their resistances. We must ensure that the metal pads are on the outside of the bend. The features of a flex sensor are as follows:

- Simple construction
- Low profile
- Angle Displacement Measurement

A flex sensor finds its applications in robotics, gaming, medical devices, computer peripherals, musical devices and physical therapy.

The electrical specifications are as follows:

- Flat Resistance- 10K
- Resistance Tolerance- 30%
- Bend Resistance Range- 60K to 110K
- Power Rating- 0.50 Watts continuous and 1 Watt peak

A common flex sensor is 4.5” in length. Figure 6 shows the Flex sensor 4.5’’ and its operation. If we try to flex towards the proximal end, it may lead to faulty reading and damage of the sensor. So the flexion should occur towards the distal end.[12]

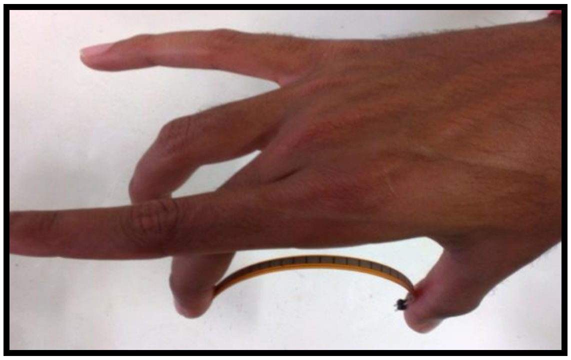


Fig 7Flex Sensor

- **Hall Effect Sensor**

A Hall Effect sensor falls under the category of a magnetic sensor. A magnetic sensor is a sensor based on the effects of electromagnetic fields. In a magnetic sensor, the disturbances caused in magnetic fields by different physical and mechanical inputs are detected. Suitable signal processing changes the final output of the sensor into desired parameters. A Hall Effect Sensor, as the name suggests, is based on the Hall Effect of the magnet. The principle of Hall Effect states that when a current carrying conductor is introduced into a magnetic field, a voltage is generated that is perpendicular to the direction of the current as well as the direction of the magnetic field. [13]

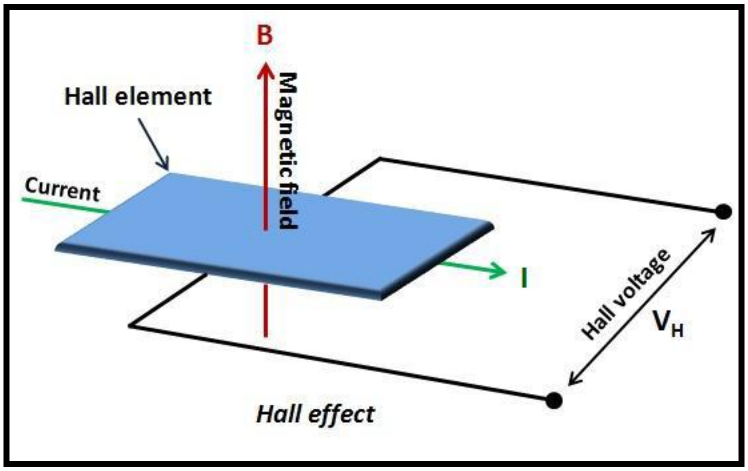


Figure 8Basic principle of Hall Effect

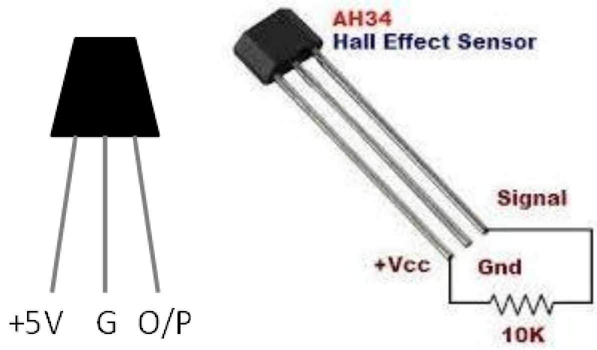
[http://embedded-lab.com]

Figure 9 illustrates the basic principle of Hall Effect. Current (I) passes through a thin plate hall element placed in magnetic field (B). It shows a thin sheet of a hall element through which a current (I) is passed and is placed in a magnetic field (B). The hall voltage obtained is directly proportional to the product of current and magnetic field. The relation between the hall voltage (VH), current (I) and the magnetic field (B) can be given by:

$$VH \propto I \times B$$

Hall Effect finds its application in proximity switching, positioning, speed detection and current sensing. Hall Effect sensors when connected with proper circuitry behaves as a switch by producing output in either of the two states, high or low. Such devices are termed as Digital Hall Effect sensors. The basic analog Hall Effect sensor can be modified into a digital one by adding a Schmitt trigger circuit, acting as a comparator.

In the figure below an Omni polar (north or south pole) Hall Effect sensor has been illustrated. As the figure shows, Hall Effect Sensor is installed with the three basic pins- +5V, Ground and output. In order to make the Hall Effect sensor compatible with various equipments, it is designed to operate at a supply voltage range of 2.5V to 5.5V and the power consumed is as low as 24uW at 3V.



(a) (b)

Fig 9- (a) Pin Configuration of a Hall Effect Sensor; (b) AH34 Hall Effect sensor with proper connections.

[http://garagelab.com/profiles/blog/show]

1.6 Push Button Switch

A push button switch or button is a simple switch is shown in the figure. Such switches are single pole single throw switches used to control certain operation in an electronic device or a machine. These are high quality omron type B3F momentary on switches made up of hard covering like that of a metal or a plastic. These types of switches usually perform well as reset switches and can be placed directly into regular bred boards for circuit design. These are rated % mA. The switch is designed in such a way that it can accommodate the hand of the user while pressing and unpressing. Pressing and unpressing of the switch leads to switch on or off respectively. Switching on of the button results into a digital HIGH of the button pin and vice-versa.[14]

Figure 10 A Push Button Switch

[http://skpang.co.uk/catalog/mini-push-button-switch-p-540.html]

1.7 16 X 2 Liquid Crystal Display (LCD)

A Liquid Crystal Display (LCD) is a very basic electronic display module used to display informations in various electronic devices and circuits. In comparison to other display devices, LCDs are cheaper and easily programmable. Moreover, LCDs are able to display special and custom characters, animations, etc. A 16 X 2 LCD corresponds to a 2 line display containing 16 characters each where each character is displayed in 5 x 7 pixel matrix.

Figure 11 A 16 X 2 LCD

[http://www.engineersgarage.com/electronic-components/16x2-lcd-module-datasheet]

Pin Number	Pin Name	Pin Function

1	Ground	Ground(0V)
2	Vcc	Supply Voltage; 5 V
3	Vee	Contrast Adjustment by a variable resistor
4	Register Select	Selection of Register (command or data)
5	Read/ Write	Read when register is LOW; Write when register is HIGH
6	Enable	Sends data to data pins
7	DB0	
8	DB1	
9	DB2	
10	DB3	8 Data Pins
11	DB4	
12	DB5	
13	DB6	
14	DB7	
15	LED+	Backlight Vcc (5V)
16	LED-	Backlight Ground (0V)

Table 3 Table listing the details of pin in an LCD

1.8 Emic 2- Text-to-speech Module

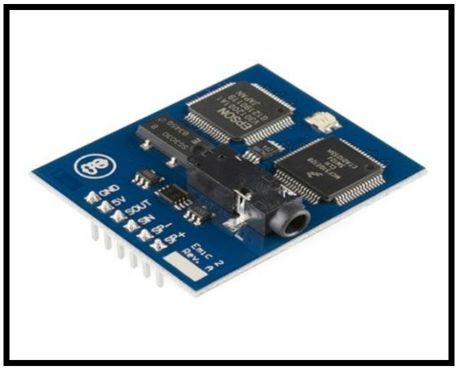


Figure 12 Emic 2- Text-to-Speech Module

[http://www.indiamart.com/vns-automation-solutions/development-board.html]

An Emic-2 Text-to-Speech module is a device that adds voice to hardware circuits through very simple connections. A 5V DC supply and a speaker connected to the speaker output (or 1/8" headphone jack) of this module produces voice in it on reception of a serial text at 9600 bps. The module consists of all supporting components to convert the text into phonemes and produce speech thereafter. Serial data is sent through microcontroller. The command consists of ASCII characters where languages, voices and speech parameters can be manipulated according to the need of the user. Speech synthesis can be done for two different languages-English or Spanish and nine different voice manipulations can be conducted. The Emic 2 Text-to-Speech module has a dimension of 1.25"x1.5"x0.37" (3.17x3.81x0.94cm). The following are the basic features of the module:

- 0.1" header is incorporated for easy connection to any hardware
- +5 V DC Supply
- Current- 30 mA idle and 46-220 mA active

- Communication- Asynchronous 9600 bps serial
- Six Pins- SN(input), SOUT(output), 5V, Ground, SP+(Speaker positive) and SP- (Speaker negative)

Such a module finds its applications in areas like read of Internet-based data streams, speaking status or sensor results from various machineries, learning language, aids for speech, etc.[21]

1.9 Objectives

Our objective is to develop a wireless attender calling system for efficient management of patient health in Intensive Care Units (ICUs) of modern and technically advanced hospitals. The device was prepared in two sections - a) the transmitter section consisting of a patient wearable (hand glove) responsible for sending of a stream of serial data through trained hand and finger movement tracking, and b) the receiver section corresponding to a patient monitoring unit aimed at reception of the stream of data, thereby responding with a display and play of desired message.

1.10 Work Plan

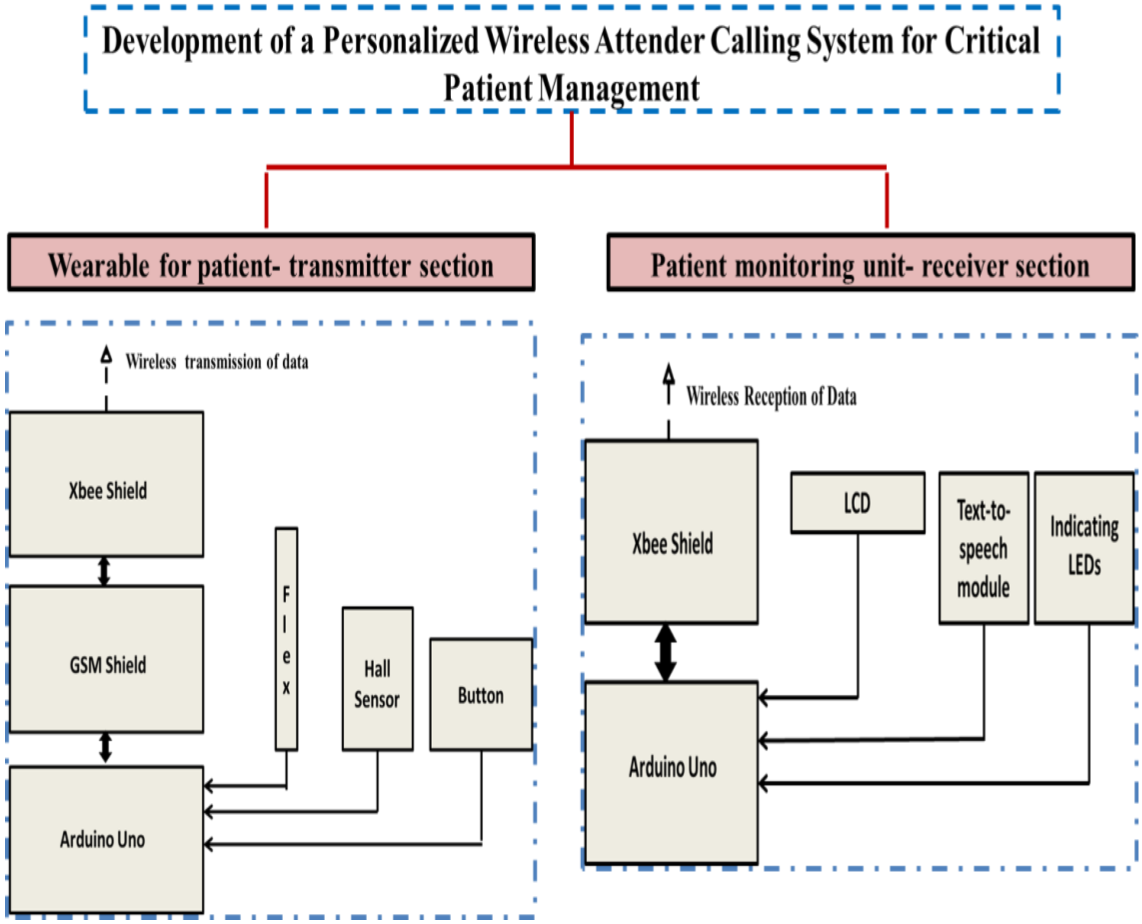


Figure 13 Flow chart showing the work plan

CHAPTER 2

MATERIALS AND METHODOLOGY

2.1 Materials

The proposed device could be broadly divided into a transmitter and a receiver section. It is principally based on an Arduino UNO platform interfaced with XBee trans-receiver supported by various sensors on the transmitter side and indicating materials on the receiver side. Theflex sensor(Spark-fun USA), Hall Effect Sensor, and SIM900 GSM/GPRS Shield constitute the transmitter section whereas, Emic-2 Text-to-Speech module plugged with speakers and 16 x 2 LCD serve as indicating components at the receiver end.

Potentiometer (10 kΩ) and resistors (10 kΩ, 22 kΩ) were used when required. PC as a monitoring unit was used at the receiver end.A mobile phone was employed for receiving text message.

2.2 Methodology

The methodology can be explained under the following broad categories:

2.2.1Design and development of the system

The proposed device principally comprises of two sections- a) the portable wearable for the patient (the transmitter section), and b) the patient monitoring unit (the receiver section). The wearable section delivers desirable commands and activates the sensors and device to obtain required response for them. This section can further be divided into three sections: i) interfacing and implementing sensors, ii) GSM Shield based SMS sending, and iii) post patient attendance confirmation. The second unit corresponds to the patient monitoring unit. This unit receives and processes the instructions delivered by the first unit. This unit can be explained in two sections- i) Attender Alerting System, and ii) MATLAB based GUI for Patient Attending System. The Block Diagram for the device.

As it is mentioned above, the system comprises two units. The patient wearable section is comprised of two sensors, three indicating LEDs, a push button switch along with the sim900 module. Flex or bend sensor Lm35 is the finger movement detector and the digital output Hall Effect sensor is the hand position detector. The activation of these sensors produces certain data from them. This data is processed by the Arduino UNO module and if anything is sensed or cross of threshold at any point, sends a wireless form of indication to the patient monitoring unit. The three LEDs serve as indicators for the activation of the sensors and the device. The push button switch comes into play once the desired purpose is fulfilled and sends information to the monitoring unit accordingly. Sim900 GPRS/GSM module sends SMS to the mobile of the concerned person. The Patient Monitoring Unit produces audio-visual indication of preset information on receiving alert sent from the patient.

2.2.2Patient Wearable Section – Transmitter Section of the Device

- **Interfacing and Implementing Sensors**

The sensor operation is managed by Arduino 1.0.5 software and programmed by AVR C programming language. The two sensors, flex sensor and Hall Effect sensor, are interfaced according to the output and their properties. The sensors are interfaced with Arduino UNO module for effective operation.

- **Interfacing Flex Sensor**

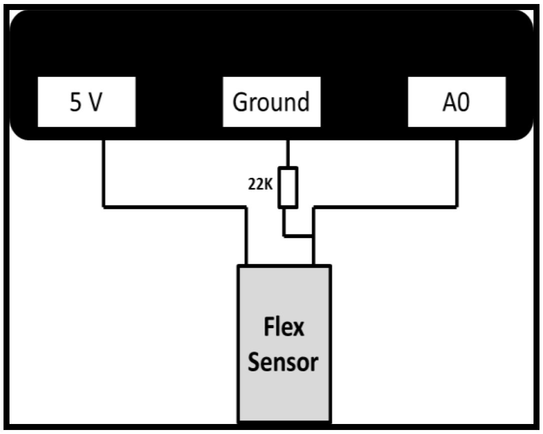


Figure 14 Pin interfacing of Flex Sensor and Arduino UNO

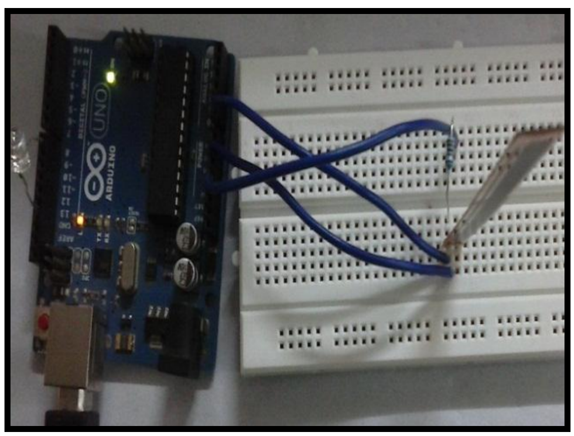


Figure 15 Snapshot of Flex sensor and Arduino UNO interfacing

Figure 14 illustrates the pin diagram of the flex sensor interfaced with Arduino UNO module. One of the two pins is connected to the power supply (5V) and the other pin is connected to the analog input of the Arduino board. A 22K resistance through this pin is grounded to the Arduino ground. Figure 15 shows the real life implementation of the interfacing. [ANNEXURE 3]

- **Interfacing Hall Sensor**

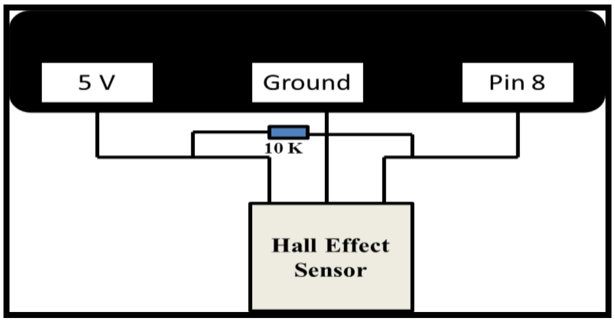


Figure 16 Pin interfacing of Hall Effect Sensor and Arduino UNO

As per figure 16, the Hall Effect sensor consists of three pins. The two pins situated on the extremities of the sensor are the output pin (Hall pin) and the power supply pin. These two pins were connected through a 10K resistor. The middle pin is the ground pin. The power supply pin and the ground pin were interfaced with the Arduino 5V and ground pins respectively. The output pin (Hall pin) was interfaced with the analog input pin of the Arduino (pin 8). [ANNEXURE 3]

Both the sensors were simultaneously implemented as follows:

The flex sensor was attached to the fore finger region of human hand glove whereas the hall sensor along with the required hardware circuitry was hung at the chest area of the patient. Now, the flex sensor analog value was read and threshold was set accordingly by appropriate coding. The reach and cross of this threshold intended to activate the sensor. On the other hand, as per as the mechanism of a Hall Effect sensor, the Hall output pin changes its state from LOW to HIGH when placed in a magnetic field. Hence, a magnetic field around this sensor activated it. This magnetic field was provided by a magnet attached to the patient glove. Movement of hand altered the distance between the magnet and the hall sensor. Occurrence of both the above events simultaneously, sends a stream of data through Xbeetransreceiver that was considered as the final indication from the patient side to the monitoring unit.[ANNEXURE 4]

The button pin was connected to the digital pin 2 of the Arduino module. The other two pins were connected to the 5V pin and ground through a 5 K resistor. On pressing the button, the digital pin 2 of the Arduino module goes HIGH. Figure 19 is the snapshot of real life implementation.[ANNEXURE 4-5]

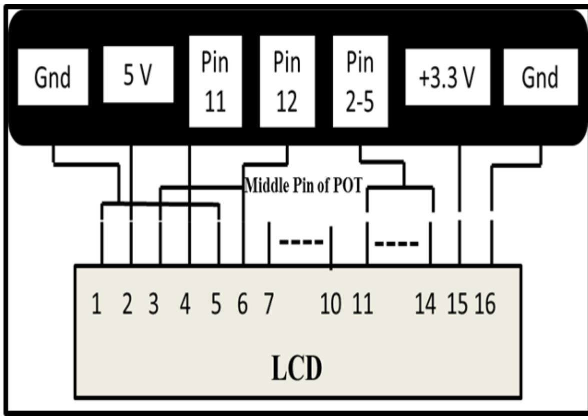
- **Arduino UNO and SIM900 GPRS/GPRS shield**

The SIM900 GPRS/GSM module was inserted with a GSM SIM card (+918093150548) and on interfacing with appropriate coding SMS consisting “Bed No. 1. Ward No. 1/ Bed No. 2. Ward No. 2” would be delivered to mobile phone (+917735311284). [ANNEXURE 5]

2.2.3 Patient Monitoring Unit – Receiver Section of the Device

- **Interfacing the LCD**

Figure 17 illustrates the connection of 16 X 2 LCD with an Arduino UNO board. Figure 18 is the snapshot of the real life connections. [ANNEXURE 10]



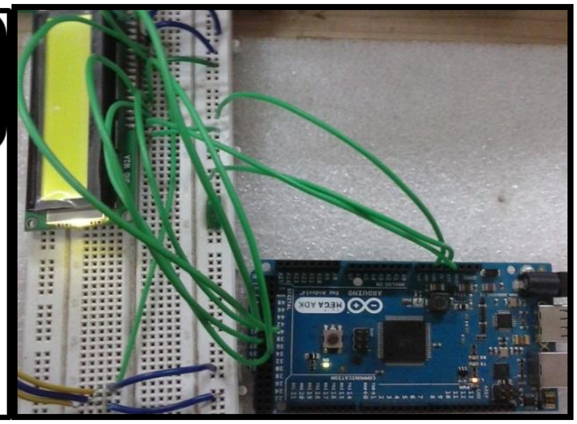
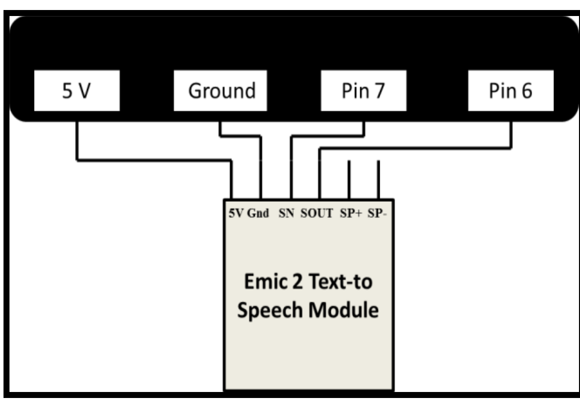


Figure 17 **Figure 18**

- **Interfacing of Emic 2 Text-to-Speech module**

Figure 19 illustrate the pin interfacing of the Emic 2 Text-to-Speech module with the Arduino module. Figure 20 is the snapshot of the real life interfacing of Emic 2 –Text-to-Speech Module. [ANNEXURE 11]



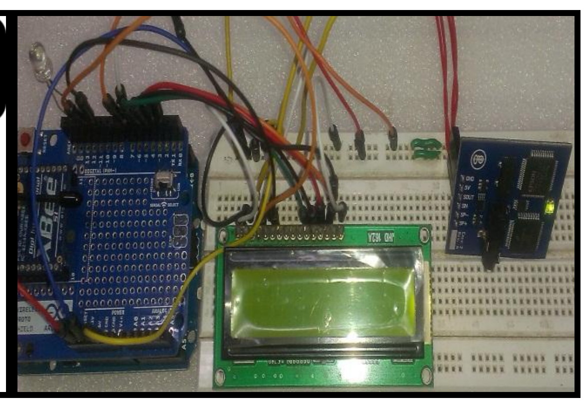


Figure 19 **Figure 20**

This completes the patient monitoring unit. Therefore, the monitoring unit contains audio visual alerts about the patient information for the consciousness of the health-caregivers in emergencies. An LCD was implanted for display of patient information. A text-to-speech module accompanied with speakers was interfaced to the circuitry to speak the required. A cell phone with specified SIM card was provided to the concerned person for further sms alerts in case of failure of the above indications.

CHAPTER 3

RESULTS AND DISCUSSIONS

3.1 Flex Sensor and Hall Sensor Analysis at the Patient side

Proper AT command was run in the Arduino UNO for the functioning of the sensors. The analog read of the flex sensor at relaxed state was observed and found to read less than 600. Keeping this in mind, the threshold level was set at 600 in the command section. Bending of the fore finger fixed with the flex sensor caused flexion of the sensor and corresponding increase in analog read was observed. The analog value increased with the bend of the flex sensor. Reach and cross of the preset threshold (=600) activated the flex sensor operation. This event was indicated by a glowing red LED on the hardware circuitry. This LED went OFF when the flex sensor was not activated.

The Hall Effect sensor was incorporated onto the hardware circuit attached to the patient's chest area. A magnetic material fixed to the wrist area of the patient's glove was assigned for the activation of the Hall Effect sensor. The performance of this Hall sensor was dependent on the strength of the magnetic field produced by the magnetic material. Hence, the activity of the Hall sensor depended on the distance between the senor and the magnetic material. Here, we observed that the Hall Sensor was active at a maximum distance range of 5-8 cm from the magnetic material. This means that the Hall sensor wound be inactive until an 8 cm distance was maintained between the wrist of the patient and the hardware circuitry. As soon as the patient would bring his hand closer to the hardware, the Hall senor started responding with a LOW to HIGH pin status.The LOW and HIGH states were indicated by two preset values in the coding.

In the vicinity of the magnet, hall sensor was found to be active and corresponding preset value was read. This event was indicated by a glowing green LED. In order to avoid any false signal from the patient side and reach maximum perfection, occurrence of both the above events simultaneously was considered as the final indication to activate the proposed. This event was achieved by trained hand movement by the patient and was indicated by a glowing orange indicating LED. A corresponding stream of data was sent through XBeetrans receiver for corresponding output on the patient side.

3.2 Indications at patient monitoring unit

As soon as the patient responded with trained hand movement thereby activating both the flex sensor and the Hall Effect sensor, a stream of data transmitted by an XBeetransreceiver was received by another XBeetransreceiver at the monitoring unit. On reception of required data, LCD displayed a message: “Ward No. 1 Bed No. 1”. Simultaneously, the text-to-speech module initiated the play of the message: “ward number 1. Bed number 1”. This message was played by speakers attached to the hardware circuitry. Shortly, SMS containing “ward no.1 bed no.1” was delivered to the mobile phone of the concerned person. Thus, a successful alert system was developed for efficient care of the patient. The entire event was indicated by two LEDs- green and red. The glowing green LED indicated the reception of required stream of data and went off immediately after the activation of the attending system. A red LED glowed continuously from the time of activation of the attending system till the patient was attended.

3.3 MATLAB Based GUI for Patient Attending System

A MATLAB based panel was developed for patient attending. The 'START' button initiated the panel software. The activation of the device displayed ward name and bed number in the panel as 'ICU' and '1' respectively. Once a health care giver was aware of the patient to be attended, use of the 'RESPOND' button on the panel led to reset of the panel. The 'EXIT' button terminated the software. Moreover, this panel displayed the ward name and bed number of the needy patient. For wearable 1, it displayed ICU as ward name and '1' as bed number. For wearable 2, it displayed ICU as ward name and '2' as bed number.

3.4 Patient Attending Confirmation

On reaching the patient's room, the health care giver would find a button on the hardware circuitry in the chest area of the patient. The concerned attender was supposed to press the button that responded with off of the red LED at the receiver end ensuring that the patient was attended. Hence, the completion of the total calling and attending was indicated by the off state of both the LEDs (red and yellow).

3.5 Demonstration and implementation of the device

Two different wearables were designed for demonstrating the working of the attender calling system for multiple patients monitoring. The device was worn by subjects (under ethical clearance) and the outcomes were observed thereafter. This survey was conducted for ten different people and their comments were recorded. This revealed that the device was working properly and the desired purpose was fulfilled. For demonstration purpose, we have considered two subjects in this paper and their corresponding results have been shown.

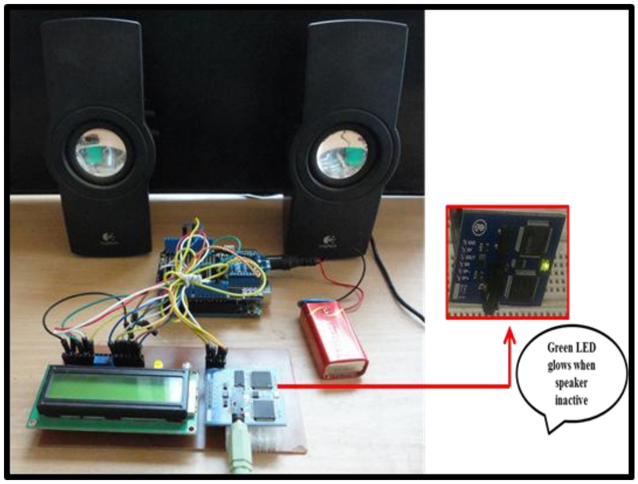
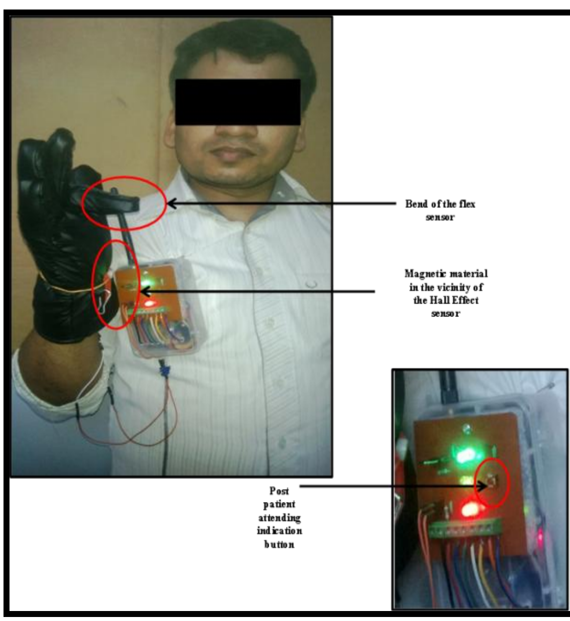


Figure 21 Initial model of the receiver unit for reference

Demonstration of wearable 1 on first subject:



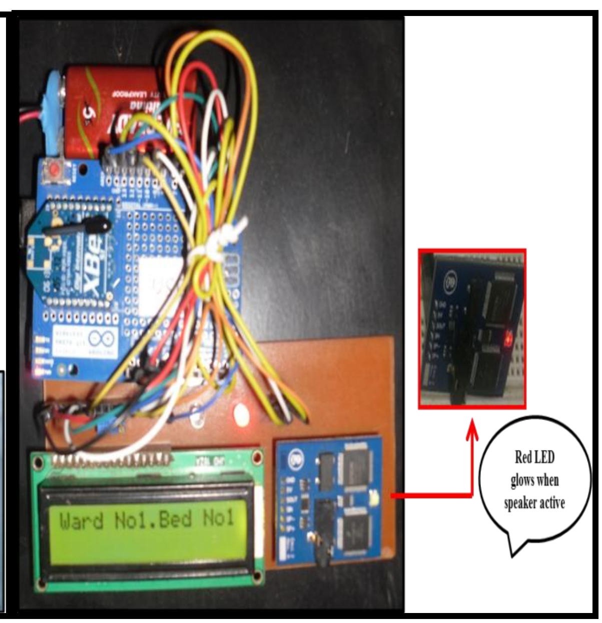


Figure 22 Transmitter Section **Figure 23 Receiver Section**

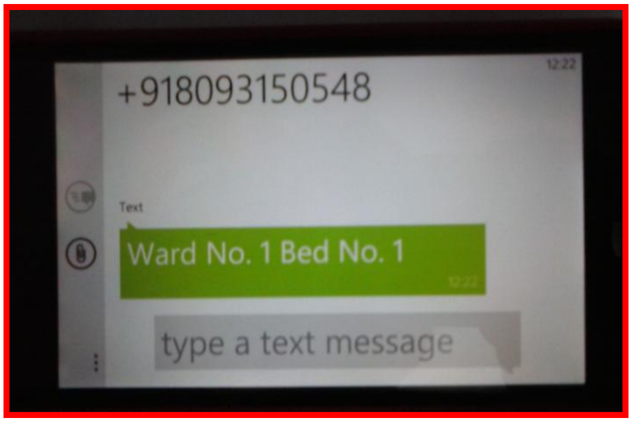


Figure 24 SMS received for subject 1(transmitter set 1)

Sensor Activation	State of Indicating LEDs
Idle	All LEDs- OFF
Flex Sensor	Red LED- ON
Hall Sensor	Green LED- ON
Both	Orange LED- ON

Table 4 State of indicating LEDs at the transmitter section

Activation of components	State of Indicating LEDs
LCD and Emic 2 Text-to-Speech module	Green LED blinks; Red LED glows
Push button switch- HIGH	Red LED goes OFF

Table 5 State of indicating LEDs at the receiver section

MATLAB Based Graphical User Interface for Patient Attendance System

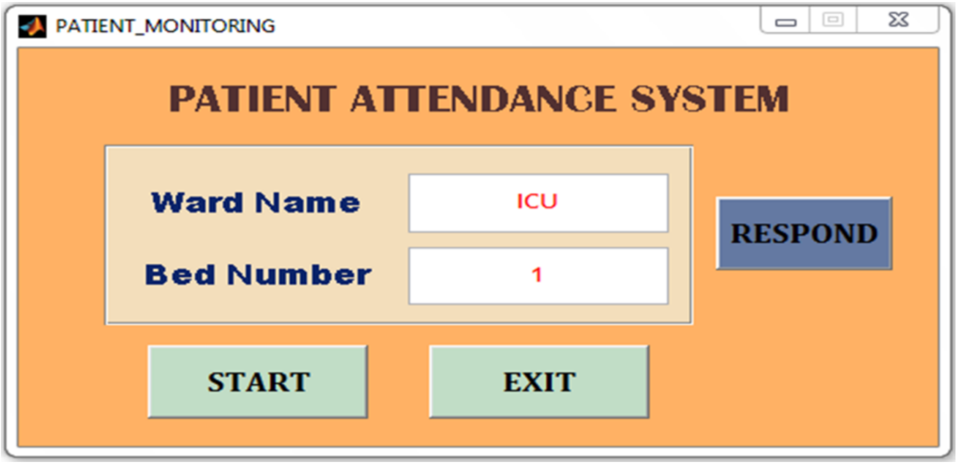


Figure 25 GUI indicating ward name and bed number for subject 1

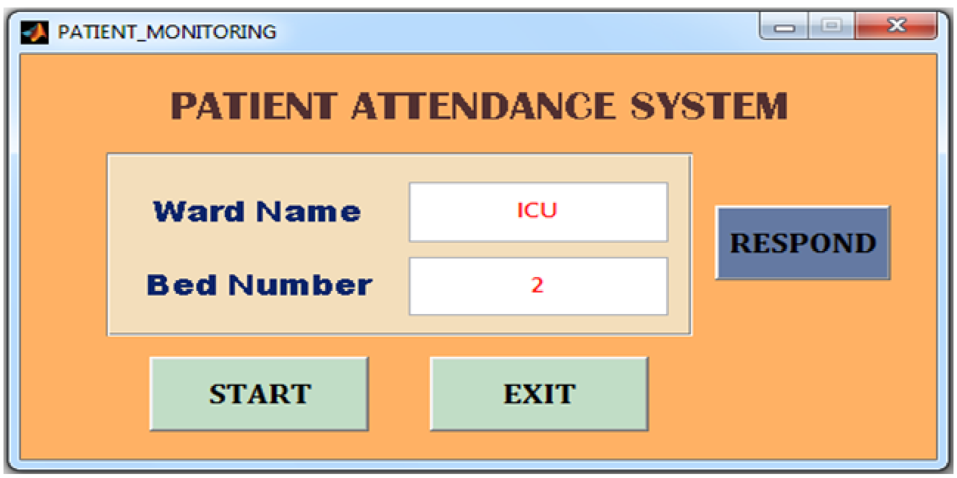


Figure 26 GUI indicating ward name and bed number for subject 2

CHAPTER 4

CONCLUSION AND FUTURE WORK

4.1 Conclusion

The proposed device, being responsive to hand movement based input of the user, generates voiced alarm, message on LCD and SMS alerts to health care-givers when required, thereby creating awareness about the patient’s health and his needs. The device may be preferred due to its simple construction and cost effectiveness. The sensitivity of the device may be manipulated depending on the mobility of the patient. This may be done by changing the threshold value of the flex sensor. Lowering of the threshold value of the flex sensor increases its sensitivity and vice-versa. One the other hand, the response of Hall Effect sensor depends upon the strength of the magnetic field produced by the magnetic material. More the strength of the magnetic field, lesser distance needs to be maintained between the magnetic material and the Hall element. Thus, we end up with a completely personalized attender calling system.

4.2 Future Work

The hospital authority often comes across with highly skeptic patients who may use the system and try to call his care-giver event not in times of need. This may harass the doctors or caregivers out of no reason. Moreover, certain patients are not conscious enough to make any hand movements so as to activate the device. To give proper assistance to such patients, we may adopt certain body-fixed sensors in replacement to the flex sensor and the Hall Effect sensor. Such sensor would aim at sensing any abnormal change in the patient’s health. Thermal sensor may be adopted as an indicating sensor that would sense any change in the patient’s body temperature, convert this parameter into electrical signal and process the same in order to activate the device. Simultaneously, other sensors may also be used depending on the patient’s health disorder. This would avoid any false indication from the patient side thereby leading to effective patient care.

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ANNEXURE 1

C language code of the system

Code for the transmitter section

For wearable 1:

```
#include <SoftwareSerial.h>
 #include <String.h>
SoftwareSerialmySerial(10,11);
 //----------------------------------
constintfsp=A0;  //FLEX
constinthallPin = 8;     // the number of the hall effect sensor pin
constint ledPin0 =11;     // the number of the LED pin
constint ledPin1=12; //FLEX// variables will change:
constint ledPin2 =13;
constintbuttonPin=2;
inthallState = 0;          // variable for reading the hall sensor status
constintther=600; //FLEX
intbuttonState=0;
int P;
//------------------------------------
void setup() {
  // initialize the LED pin as an output:
pinMode(ledPin0, OUTPUT);
pinMode(ledPin1,OUTPUT);
pinMode(ledPin2,OUTPUT);
  // initialize the hall effect sensor pin as an input:
pinMode(buttonPin,INPUT);
```

```
pinMode(hallPin, INPUT);
digitalWrite(ledPin0,LOW);
digitalWrite(ledPin1,LOW);
digitalWrite(ledPin2,LOW);
digitalWrite(buttonPin,LOW);
mySerial.begin(9600);
Serial.begin(9600);

delay(100);
}
//-------------------------------------
void loop()
    {
buttonState=digitalRead(buttonPin);
if(buttonState==HIGH)
    {
Serial.println(3);
    }
else
    {
delay(100);
    }
intfsr= analogRead(fsp);
Serial.print("fsr=");
Serial.println(fsr);
```

```
if(fsr<ther)
    {
digitalWrite (ledPin0, HIGH);
    }
else
    {
digitalWrite(ledPin0, LOW);
delay(100);
    }
hallState = digitalRead(hallPin);
if (hallState == LOW)
  {
digitalWrite(ledPin1, HIGH);
P=100;
Serial.println(P);
   }
else
  {
digitalWrite(ledPin1, LOW);
     P=700;
   // Serial.print('P=');
Serial.println(P);
    //Serial.println('0');
```

ANNEXURE 4

```
delay(100);
  }
if (fsr<ther& P<ther)
  {
digitalWrite(ledPin2, HIGH);
//Serial.println('0');
Serial.println(1);
SendTextMessage();
  }
else
   {
digitalWrite(ledPin2, LOW);
    //Serial.println('0');
   }
delay(100);
   }
voidSendTextMessage()
{
mySerial.print("AT+CMGF=1\r");    //Because we want to send the SMS in text mode
delay(100);
mySerial.println("AT + CMGS = \"+917735311284\"");
delay(100);
mySerial.println("Ward No. 1 Bed No. 1");//the content of the message
delay(100);
mySerial.println((char)26);//the ASCII code of the ctrl+z is 26
```

```
delay(100);
mySerial.println();
}
```

For wearable 2:

```
#include <SoftwareSerial.h>
 #include <String.h>
SoftwareSerialmySerial(10,11);
 //----------------------------------
constintfsp=A0;  //FLEX
constinthallPin = 8;     // the number of the hall effect sensor pin
constint ledPin0 =11;     // the number of the LED pin
constint ledPin1=12; //FLEX// variables will change:
constint ledPin2 =13;
constintbuttonPin=2;
inthallState = 0;          // variable for reading the hall sensor status
constintther=600; //FLEX
intbuttonState=0;
int P;
//------------------------------------
void setup() {
  // initialize the LED pin as an output:
pinMode(ledPin0, OUTPUT);
pinMode(ledPin1,OUTPUT);
pinMode(ledPin2,OUTPUT);
```

```
pinMode(buttonPin,INPUT);
pinMode(hallPin, INPUT);
digitalWrite(ledPin0,LOW);
digitalWrite(ledPin1,LOW);
digitalWrite(ledPin2,LOW);
digitalWrite(buttonPin,LOW);
mySerial.begin(9600);               // the GPRS baud rate
Serial.begin(9600);    // the GPRS baud rate
delay(100);
}
//-------------------------------------
void loop()
    {
buttonState=digitalRead(buttonPin);
if(buttonState==HIGH)
    {
Serial.println(3);
    }
else
   {
delay(100);
    }
intfsr= analogRead(fsp);
Serial.print("fsr=");
```

```
Serial.println(fsr);
if(fsr<ther)
    {
digitalWrite (ledPin0, HIGH);
    }
else
    {
digitalWrite(ledPin0, LOW);
delay(100);
    }
hallState = digitalRead(hallPin);

if (hallState == LOW)
  {
digitalWrite(ledPin1, HIGH);
     P=100;
Serial.println(P);
   }
else
  {
digitalWrite(ledPin1, LOW);
     P=700;
   // Serial.print('P=');
Serial.println(P);
```

```
delay(100);
}
if (fsr<ther& P<ther)
{
digitalWrite(ledPin2, HIGH);
   //Serial.println('0');
Serial.println(2);
SendTextMessage();
  }
else
   {
digitalWrite(ledPin2, LOW);
   //Serial.println('0');
   }
delay(100);
   }
voidSendTextMessage()
{
mySerial.print("AT+CMGF=1\r");    //Because we want to send the SMS in text mode
delay(100);
mySerial.println("AT + CMGS = \"+917735311284\"");//send sms message, be careful need to add a country code before the cellphone number
delay(100);
mySerial.println("Ward No. 2 Bed No. 2");//the content of the message
delay(100);
mySerial.println((char)26);//the ASCII code of the ctrl+z is 26
```

```
delay(100);
mySerial.println();
}
```

ANNEXURE 9

Code for the receiver section

```
#include <SoftwareSerial.h>
#include <LiquidCrystal.h>
  #define rxPin 6    // Serial input (connects to Emic 2 SOUT)
  #define txPin 7    // Serial output (connects to Emic 2 SIN)
  #define ledPin1 13  // Most Arduino boards have an on-board LED on this pin
  #define ledPin2 9
int m;
  // set up a new serial port
SoftwareSerialemicSerial=  SoftwareSerial(rxPin, txPin);
LiquidCrystallcd(12,11,5,4,3,2);

void setup()  // Set up code called once on start-up
  {
    // define pin modes
pinMode(ledPin1, OUTPUT);

pinMode(ledPin2, OUTPUT);
pinMode(rxPin, INPUT);
pinMode(txPin, OUTPUT);
```

```
Serial.begin(9600);
   // set the data rate for the SoftwareSerial port
emicSerial.begin(9600);
digitalWrite(ledPin1, LOW);  // turn LED off


digitalWrite(ledPin2, LOW);
emicSerial.print('\n');             // Send a CR in case the system is already up
while (emicSerial.read() != ':');
delay(10);                          // Short delay
emicSerial.flush();                 // Flush the receive buffer
lcd.begin(16, 2);
}
void loop()  // Main code, to run repeatedly
  {
while(Serial.available() > 0) {
     m = Serial.read();
char t=m;
if(t == '1')
    {
   // Speak some text
emicSerial.print('S');
emicSerial.print("Ward Number 1.Bed Number 1.");
lcd.print("Ward No1.Bed No1.");  // Send the desired string to convert to speech
emicSerial.print('\n');
digitalWrite(ledPin1, HIGH);        // Turn on LED while Emic is outputting audio
```

```
digitalWrite(ledPin2, HIGH);
while(emicSerial.read() != ':');
digitalWrite(ledPin1, LOW);
lcd.setCursor(0, 1);
  // print the number of seconds since reset:
  //lcd.print(millis()/1000);
Serial.println(t);
    }
if(t == '2')
    {
    // Speak some text
emicSerial.print('S');
emicSerial.print("Ward Number 2.Bed Number 2.");
lcd.print("Ward No2.Bed No2"); // Send the desired string to convert to speech
emicSerial.print('\n');
digitalWrite(ledPin1, HIGH);         // Turn on LED while Emic is outputting audio
digitalWrite(ledPin2, HIGH);
while (emicSerial.read() != ':');
digitalWrite(ledPin1, LOW);
    // set the cursor to column 0, line 1
  // (note: line 1 is the second row, since counting begins with 0):
lcd.setCursor(0, 1);
  // print the number of seconds since reset:
  //lcd.print(millis()/1000);
    }
```

```
if(t == '3')
    {
digitalWrite(ledPin2,LOW);
delay(500);    }
```